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Effect of concentrate supplementation on herbage intake and live weight gain of sheep grazing a semi-arid grassland steppe of North-Eastern Asia in response to different grazing management systems and intensities ☆

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ABSTRACT

An increasing human population and growing demand for food of animal origin intensified livestock production and lead to overgrazing and desertification in semi-arid grass lands. Strategies for sustainable livestock production that protect steppe vegetation and satisfy farmers' economic interests are strongly needed. This study analysed the effects of a moderate concentrate supplementation on organic matter digestibility (dOM), organic matter intake (OMI), metabolisable energy intake (MEI), and live weight (LW) gain of sheep grazing at different intensities to evaluate its potential contribution to profitable livestock production at conservative stocking densities (SD). In 2010, a grazing experiment was conducted in the Xilin River Basin, the Inner Mongolian steppe, China (E116°42′ N43°38′) using 337 female Mongolian fat-tailed sheep (30.2 ± 4.3 kg LW). The effect of concentrate supplementation was tested in two different grazing management systems and six classes of herbage allowances (HA). While experimental plots had only been used for grazing in previous years in the continuous system, grazing and hay-making had been alternated annually on plots of the alternating system. The SD ranged from light to heavily grazed with 2.1–10.3 sheep/ha and were adjusted every month to maintain similar HA across the grazing season. Four sheep per plot received 250 g/d of a corn–wheat-based concentrate feed (SUP), while four non-supplemented (NSUP) sheep were used as control. Faecal samples were collected on five days each in July, August, and September. The dOM was estimated from faecal crude protein concentration and faeces excretion quantified using the marker titanium dioxide. The animals were weighed monthly to determine daily LW gain. The dOM was higher in SUP than NSUP sheep (0.557 vs. 0.533, RSD: 0.016). As a consequence, daily OMI and LW gain of SUP sheep (74 g/kg$^{0.75}$ LW; 121 g) were higher than of NSUP sheep (68 g/kg$^{0.75}$ LW, RSD: 6.4; 86 g, RSD: 24.6) despite a decrease in herbage OMI of 0.41 g per 1 g concentrate feed. Grazing system had no influence on dOM, OMI, or LW gain of sheep. The effects of supplementation were independent of HA class, and OMI, herbage OMI, MEI, and LW gain were higher in the beginning than in the end of the experiment. Moderate concentrate supplementation to grazing sheep strongly

☆ This publication is dedicated to Dr. Herbert Steingaß on his 60th. birthday.

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increases LW gain of individual animals and might offer a valuable contribution to increase individual productivity, maintaining the output per area at lower SD. A reduced herbage OMI alleviates grazing pressure and can thus maintain long-term grassland productivity.

1. Introduction

As a consequence of an increasing population and a growing demand for animal products livestock densities worldwide have strongly increased in the last decades (Mortimore, 1993). In pastoral systems of the semi-arid and arid regions of North-Eastern Asia, overgrazing is thus considered as the main reason for degradation and desertification of natural rangelands (Zhao et al., 2005; Akiyama and Kawamura, 2007).

Due to higher feed and energy intakes and consequently, higher animal performances, supplemental feeding may allow for a reduction in stocking densities (SD) to protect the vegetation without compromising for the total animal mass output per unit of land area (Caton and Dhuyvetter, 1997). However, the efficiency of supplementation (i.e. additional output per kg of feed offered) is affected by several factors such as the species, breed, or age of the animal (Southgate et al., 1982; Lourenco et al., 2000) and the type of supplement feed offered (Fahmy et al., 1992). Moreover, the amount and nutritional quality of the plant biomass available for grazing (Caton and Dhuyvetter, 1997) and thus any grazing management decisions may directly or indirectly alter the efficiency of supplemental feeding. Hence, this study analysed the effects of concentrate supplementation on feed intake and performance of sheep grazing the semi-arid steppe vegetation in Inner Mongolia at different SD and grassland management systems.

We hypothesised that (i) efficiency of concentrate supplementation will be higher at a continuous grazing management system (CON) than in a alternating grazing management system (ALT) due to a lower ground cover, differences in the botanical composition of the vegetation, and thus, an inferior mass and feeding value of the available forage at CON. Moreover, the ability of animals to select for plant species or parts of higher feeding value is limited, when feed allowances are low. Altogether, this might result in greater increases in diet digestibility, lower forage replacement rates, and therefore an enhanced total feed intake of animals at CON than at an ALT system. Similarly, mass and nutritional quality of the vegetation as well as the selective feeding behaviour is inferior at low than at high herbage allowance (HA). Hence, we expected that (ii) the effect of concentrate supplementation will be more pronounced at very low HA and (iii) in the end of vegetation and grazing period.

2. Material and methods

2.1. Study area

The study was conducted in the Xilin River Basin in the Inner Mongolia Autonomous Region of China (E116°42′ N43°38′) during vegetation period (May–September) of 2010. The study area is located on the Mongolian Plateau at about 1200 m above sea level. It belongs to the Inner Mongolia Grassland Ecosystem Research Station which is administered by the Institute of Botany of the Chinese Academy of Science, Beijing. The area had been moderately used for sheep grazing until October 2003. Afterwards, it had not been grazed until a multiannual grazing trial was established in June 2005 which comprised our study. The semiarid continental climate is characterised by a mean annual precipitation of 296 mm (2003–2010) and a mean annual air temperature of 1.4 °C. It is typical for the temperate steppe region with high intra- and inter-annual variability in precipitation. The Eurasian steppe is the largest connected grassland ecosystem of the world (Bai et al., 2008). About 73% of provincial area is grassland (0.9 million km^2) and used for sheep, goat, cattle, and camel grazing in pastoral livestock and mixed crop-livestock farming systems. Annual above-ground net primary production of the grassland (ANPP) is about 1423 kg dry matter (DM)/ha (Schonbach et al., 2011) and highly variable depending on the amount of rainfall (Yu et al., 2004). The perennial rhizome grass *Leymus chinensis* Trin. Tzvel. and the perennial bunchgrass *Stipa grandis* P. Smirn. Characterise the typical steppe plant communities (Bai et al., 2004). The major soil types are calcic chestnuts and calcic chernozems (IUSS Working Group WRB, 2007). The grassland steppe is a fragile ecosystem and extensively degraded by severe overgrazing (Christensen et al., 2004).

2.2. Experimental design

Sheep were transferred to the grazing area on 12th of June and removed from pastures on 10th of September, resulting in a grazing period of 91 days. The experimental area (128 ha) was divided in grazed areas that were used for sheep grazing and ungrazed areas that were utilised for cutting hay. We investigated two different grazing management systems. The first system was an ALT grazing system where the same plots had been used alternately for animal grazing in the first and for haying in the next year since 2005. The second system was a CON grazing system where the same plots had either been used for animal grazing or for harvesting forage every year. The latter system is similar to the current grassland management in Inner Mongolia. In every system six different HA classes were realized on two plots each used as replicates. Therefore measurements were carried out on a total of 24 randomized grazing plots (2 systems × 6 HA classes × 2 replicates). Since HA will better describe grazing intensity than SD, if herbage mass (HM) differs between experimental plots or throughout the grazing period (Sollenberger et al., 2005), HA classes were used

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